J.4.5 Climate, fuels, fire and decisions:
The making of national monthly and seasonal wildland fire outlooks

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1. INTRODUCTION

The record setting wildfire season of 2000 sent a shockwave through land management agencies and political bodies. A wildfire somewhere in the U.S. was reported every single day of the year. Not seen in more than half a decade, over 8 million acres burned from approximately 123,000 fires. Federal fire suppression costs exceeded $2 billion. Other costs, though not precisely known as a grand total, were state and local suppression efforts, direct and indirect economic losses from impacted communities, loss of property and damaged ecosystems.

Cerro Grande and the northern Rockies fires culminated the 2000 season, and even by August, then-President Clinton directed the Secretaries of Agriculture and Interior to develop a response to the national fire problem. What followed in 2001 was a revision of the 1995 Fire Policy to improve its implementation, the establishment of the National Fire Plan, a stakeholder driven 10-year comprehensive strategy, and an infusion of nearly two billion dollars for firefighting, rehabilitation/restoration, hazardous fuels reduction, community assistance and accountability. Clearly, the response was not just directed at fire suppression. For the first time in the history of U.S. wildfire business, significant pro-active strategies were openly encouraged within all of these facets simultaneously.

Of the numerous outcomes of this new opportunity were the hiring of approximately 20 national interagency fire weather meteorologists, and the establishment of Predictive Services, a concept to provide integrated information and forecasts of weather, climate, fuels and fire. The meteorologists were primarily hired to add value to existing weather data and forecasts in the context of fire and fuels information being assessed by agency fire intelligence personnel, and fire and fuels specialists. Predictive services was chartered to “integrate climate, weather, situation, resource status and fuels information into products that will enhance the ability of managers to make sound decisions for both short and long range strategy development and resource allocation decisions, and ensure the safety of firefighting and emergency personnel” (http://www.nifc.gov/news/pred_services/Main_page.htm).

For the past several decades it has been common for fire management to utilize daily fire weather forecasts for tactical decisions, but any predictions much longer than a day or two usually have not been of direct interest. However, perhaps tied to limited available resources, new management objectives, accountability, and advances in available tools and information, a value in longer-range products is now being recognized for strategic planning.

In March 2003, for the first time ever, a team of fire weather meteorologists, fire and fuels specialists, management and climatologists met to produce the first comprehensive seasonal fire potential outlook for the U.S. The outlook incorporated past, present and future information of climate and fuels, along with an accumulated knowledge base of how these relate to fire. The workshop, co-organized by the National Interagency Coordination Center (NICC; Predictive Services), the NOAA-funded Climate Assessment for the Southwest (CLIMAS; University of Arizona), and the Program for Climate, Ecosystem and Fire Applications (CEFA; Desert Research Institute), included four tangible products: 1) geographic area wildfire outlook reports; 2) standardized protocols for producing long-range fire danger outlooks; 3) two seasons of 2003 consensus climate forecasts for wildfire fire management; and 4) a NICC pre-season national wildfire fire outlook.

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The workshop process provided a model and mechanism for increasing organizational capacity, enhancing multi-agency collaboration, improving the use of forecast information and climatological analysis, and transitioning the results of research to an operational process for improved communication and decision making. Detailed discussion of the workshop can be found in Garfin et al (2003).

2. GEOGRAPHIC AREA OUTLOOKS

A key element to the success of producing a useful forecast was breakout groups that focused on specific geographic area issues. Figure 1 shows the eleven interagency geographic area coordination centers (GACCs). The primary responsibility of a GACC is to provide logistical support and fire, weather and fuels intelligence for anticipated and ongoing wildfire activity for all federal and cooperating state fire suppression agencies. During the breakout sessions, each GACC group met in a round-table setting to discuss relevant issues of weather, climate and fuels that could significantly impact the upcoming season. Historical, present and predicted conditions were emphasized in the discussion. Historical information largely included the past winter season precipitation, a longer-term drought perspective and carry over fuels (those that may normally be reduced during winter; for example, grasses compacting from snow). The present situation primarily included the current state of the fuels, particularly fuel moisture characteristics (e.g., loading, vertical and horizontal continuity). Seasonal predictions focused on climate (temperature and precipitation) and fuel conditions.

The final outlook product was a combination of this quantitative information and forecaster judgment. Considerable experience and knowledge was incorporated into the forecast process. In other words, the forecasts were by no means strictly quantitative based. Forecast uncertainty was primarily addressed by assigning likelihoods to worst-, best-, and average-case scenarios. The high degree of coordination, communication, and cooperation within and between geographic area workgroups ultimately lead to the overall success of the workshop.

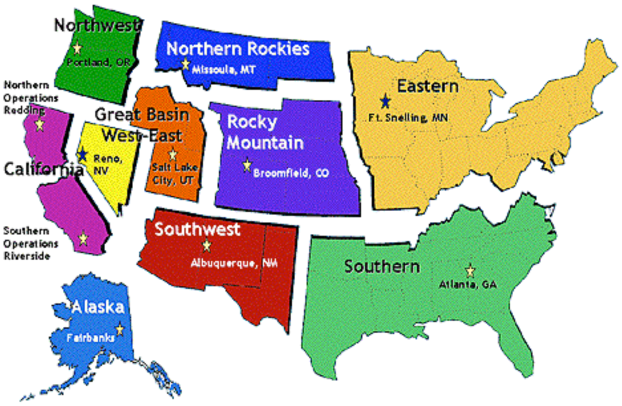

Figure 1. Interagency geographic areas.

The text and accompanying photo (Figure 2) below is an example of the seasonal outlook combined from the two California GACCs. This executive summary describes conditions expected for the state during the 2003 fire season as written in late February. The photo is provided to illustrate the drought/bug killed timber in the forested area around Lake Arrowhead as noted in the text. The concern about mortality and fire became reality at the end of October when very extensive wildfires with extreme fire behavior occurred in largely populated intermix areas near Los Angeles and San Diego. The Lake Arrowhead forest was not burned this time, but largely because of a rapidly changing weather system that brought increased moisture, precipitation and much cooler temperatures to the region as the fire front encroached the surrounding lake area.

N. and S. California: **Potential: Normal to Above Normal.** There are two particular areas of concern regarding fuel conditions in California. One is the drought-affected, large dead fuel moistures of the Eastern Modoc plateau and eastside of northern California. The second concern is the significant brush mortality and drought/bug-killed timber areas of Southern California (see image). The Los Padres, Angeles, and Cleveland National Forests have low to moderate levels while the San Bernardino NF has moderate to high levels of brush and timber mortality. These are likely to cause extreme fire behavior even under moderate fire weather/fire danger conditions. Indications from the current weather and climate outlook are that fire season will start in the typical time frames across much of California. However, the drier eastside areas will see fire season start earlier and be of longer duration than normal. Fire danger is expected to be above average in all parts of the state except the western two-thirds of northern California. Lightning occurrence in Northern California has a very good chance of exceeding that in 2002, as last year was well below the 10-year average amount.

Figure 2. Timber area near Lake Arrowhead, CA showing tree mortality from drought and bug kill. (Photo source: California Department of Forestry and Fire Protection)

The verification of these forecasts is an area just beginning to be addressed. Formalized definitions and processes for quantitative verification need to be established. This process has been initiated, and will continue in Predictive Services workshops and other relevant forums.

3. CONTENT AND PROTOCOLS

The final format of the area outlooks included an executive summary, introduction and objectives of the report, current conditions, climate and weather outlooks, fire occurrence and resource outlooks, future scenarios and probabilities, management implications, and concerns and summary recommendations. These protocols will be used in the preparation of succeeding outlooks. As might be expected, the executive summary is a synthesis of the key findings (such as in the California example above) that a fire manager could read in brief. The report introduction and objectives are straightforward by primarily defining the purpose of the outlook and how it might be used. Current conditions provides for a lengthy treatment of all physical elements that could impact the fire season. The climate and weather outlooks primarily focus on specific long-lead outlooks, ENSO conditions, drought forecasts and fire weather indices. Fire occurrence and resource outlooks are based upon some quantitative tools, but are perhaps more qualitative components of the outlook at present. The expected resources are largely based on experience, i.e., knowing what resources have been required in the past given a particular fire season scenario. The future scenarios and probabilities utilize some decision support tools along with fuel and climate considerations developed in part from previous experience and current season knowledge. Management implications and concerns address how the predicted climate and fuels might impact management decisions and strategies. Finally, the summary and recommendations suggest how the outlook information might be utilized. Table 1 shows the outlook report content and some specific protocols to be considered.

4. CONSENSUS CLIMATE FORECAST

The primary purpose of producing a national consensus climate forecast was three-fold: 1) to produce seasonal climate forecasts for use in developing a national seasonal wildfire outlook; 2) to determine whether or not additional probabilistic information could be provided for areas where individual forecasts showed little confidence; and 3) to directly integrate climate forecast information into specific stakeholder decision-making. A fourth aspect of this process was that it allowed fire specialists to interact directly with climate experts, and vice versa. Agencies that participated in this project included the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC), the NOAA – Cooperative Institute for Research in Environmental Sciences (CIRES) Climate Diagnostics Center (CDC), the International Research Institute for Climate Prediction (IRI) and the Scripps Institution of Oceanography Experimental Climate Prediction Center (ECPC).

Seasonal forecasts of two-category probabilistic temperature and precipitation departures from average were produced for the contiguous United States and Alaska. Forecast consensus was reached by combining several monthly and seasonal forecasts produced at CDC, CPC, ECPC and IRI. The forecast periods were March-April-May (MAM) and June-July-August (JJA) 2003. A combination of dynamical and statistical models from the respective organizations, and forecaster judgment were incorporated in producing the forecasts. Specifically, the IRI contribution was their most current seasonal forecasts based on the CCM3.2

(developed at the National Center for Atmospheric Research), ECHAM4.5 (developed at the Max Plank Institute), NCEP-MRF9 (developed at the National Centers for Environmental Prediction), COLA2.x (developed at the University of Maryland), and NSIPP (developed at the National Aeronautics and Space Administration) models and sea surface temperature predictions (Mason et al. 1999). The ECPC contribution included current monthly forecasts from two versions of the Global Spectral model as well as the Regional Spectral Model (Roads et al. 2001; Kanamitsu et al. 2002). The CPC contribution was the current seasonal long-lead outlooks based on a dynamical model, a statistical model, and long-term trend (http://www.cpc.ncep.noaa.gov/products/predictions/90day). The CDC contribution was based on a newly developed statistical model and analysis for precipitation forecasts in the southwest U.S. (http://www.cdc.noaa.gov/~kew/SWcasts/index.html). In addition, it was based on ENSO composites for MAM and JJA during rapidly declining El Niño phases. These objective forecasts were then combined with forecaster judgment including model forecast skill, temperature versus precipitation correlations and current ENSO opinions.

The forecasts were produced during a round-table forum at the workshop. Forecast discussion lead to determining regions of warm/cool and dry/wet, and assigning a consensus probability. Since the forecasts were comprised of only two categories, the probabilities simply represent the chance of above or below normal. For example, if the forecasters determined a 10% chance of the above normal category occurring, then the probability of the above normal category became 50% + 10%, or 60%. Increasing percent values above 50 indicates a relative increase in forecast confidence. Given the current state of art for climate forecasting, 55% would be considered low confidence (only a slight hedge), and 70% high confidence. A forecast probability of 50% means no forecast confidence for either category. Figure 3 shows the temperature and precipitation consensus March-April-May seasonal forecasts for the contiguous U.S. Further detail of these forecasts can be found in Brown et al (2003).

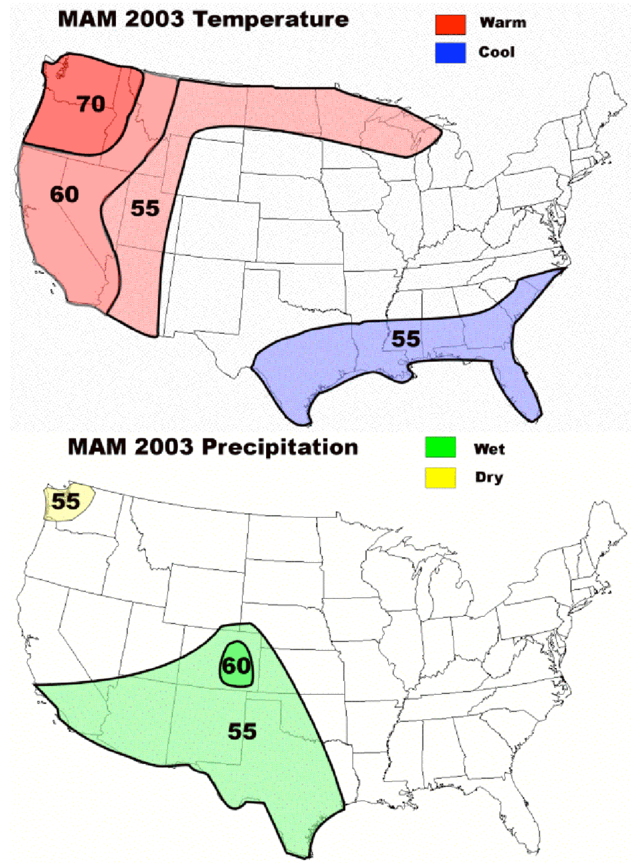

Figure 3. Temperature (top) and precipitation (bottom) consensus March-April-May seasonal forecasts for the contiguous U.S. Above (warm/wet) and below (cool/dry) temperature and precipitation are denoted by red/green and blue/yellow colors, respectively. Probabilities are given in bold numbers. No color shading denotes areas of no forecast confidence.

5. NATIONAL FIRE POTENTIAL OUTLOOK

One of the desired outcomes of the workshop was to produce a national fire potential outlook. This product would be primarily utilized by NICC as guidance for seasonal allocation planning of national suppression resources, and for fire management and congressional briefings. A one-page flyer discussing the seasonal forecast was produced and distributed for the purpose of a synthesis briefing at the Washington level. The national fire potential map shown in Figure 4 was produced by the integration of the GACC regional outlooks. Geographic areas of above or below normal potential are highlighted with red and green shading, respectively. Fire potential in this context has yet to be well defined in a quantitative manner. This will occur with the evolution of Predictive Services and this particular product. For now, potential generally refers to areas that may have departures from normal in terms of numbers of fires or area burned or a combination of both, but such that there may be significant impacts on suppression resources. For example, a higher demand for resources may be needed in the above normal areas, and a lower demand in the below normal areas. However, the type and extent of resources might vary depending on the fuel types and the reasons for the prediction (e.g., long-term drought with no expected recovery, vegetation mortality, short-term precipitation deficits, etc.). The map shading does not necessarily imply anomalous potential for the entire six-month period, though this could be possible. The monthly and 10-day forecasts that each GACC produces better address the intraseasonal variability that usually occurs. Though this paper has focused primarily on the development of a seasonal forecast, the monthly forecasts are done within each GACC, utilizing much of the same information.

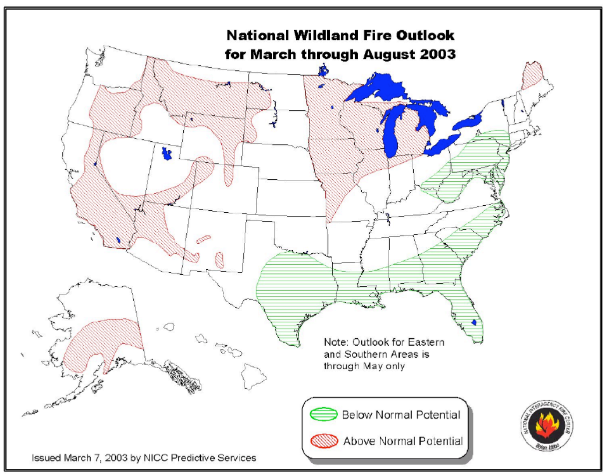

Figure 4. National wildland fire outlook for March though August 2003.

6. CONCLUSION

The objectives of the workshop were to establish protocols for producing monthly and seasonal fire outlooks utilizing integrated information of climate, fuels and fire. Participant feedback was encouraged during the workshop in order to improve the structure and mechanisms of producing seasonal outlooks and their content. Communication between climate forecasters and GACC specialists was strongly encouraged. An outcome of the workshop that was not explicitly predicted was the strong communication and cooperation between the GACCs. In fact, the whole process was a remarkable synergy between a large number of individuals with varying areas of expertise and opinions to produce a regional forecast of fire potential, that by definition, has to include climate, weather, fuels and fire components. The definition also has to include decisions, not only during the making of the seasonal forecast itself, but during the utilization of the product by decision-makers in a manner that leads to effective outcomes.

There has not been developed a quantitative method for determining the success of the seasonal fire outlook. However, there will be two workshops in 2004 to again produce seasonal outlooks. The first workshop will be held in late January and focus on the eastern U.S., a region that typically has two fire seasons – spring and autumn. The second workshop will be held in early April, and will be national in scope, though much emphasis will be placed on the West where the bulk of fires occur in summer. The simple fact that these workshops are desired suggests a level of success. The making of these forecasts has provided an opportunity for specialists to think in detail about the various pieces of the fire puzzle, and integrate them by thought and communication into a coherent picture comprised of many physical factors. At the very least, fire management has a support tool to allow for proactive thinking and to provide accountability for decisions.

7. REFERENCES

Brown, T.J., A.G. Barnston, J.O. Roads, R. Martin, and K.E. Wolter, 2003: 2003 Seasonal Consensus Climate Forecasts for Wildland Fire Management. *Experimental Long-Lead Forecast Bulletin*, March 2003, Vol. 12, 4 pp.

Garfin, G., T. Wordell, T. Brown, R. Ochoa and B. Morehouse, 2003. *National Seasonal Assessment Workshop*, Final Report, University of Arizona, 24 pp. [Available at http://www.ispe.arizona.edu/climas/]

Kanamitsu, M., A. Kumar, H.-M. H. Juang, W. Wang, F. Yang, J. Schemm, S.-Y. Hong, P. Peng, W. Chen and M. Ji, 2002: NCEP Dynamical Seasonal Forecast System 2000. *Bull. Amer. Met. Soc.*, **83**, 1019-1037.

Mason et al., 1999: The IRI seasonal climate prediction system and the 1997/98 El Nino event. *Bull. Amer. Meteor. Soc.*, **80**, 1953-1873.

Roads, J.O., S-C. Chen and F. Fujioka, 2001: ECPC's Weekly to Seasonal Global Forecasts. *Bull. Amer. Meteor. Soc*, **82**, 639-658.

Table 1. Fire potential seasonal outlook content and protocols.

A. Executive Summary

1. A specific forecast statement (i.e., “the bottom line”) should be explicitly included in the executive summary and final summary and recommendations. Include a statement about your confidence in the forecast. Mention why you do or do not have confidence, based on your assessment of the various tools used in your forecast.

B. Introduction and Objectives

1. Include guidelines for use of the report and a disclaimer.

C. Current Conditions (including comparison with historical records)

1. Snow (SNOTEL data, SWE)
2. Precipitation anomalies (recent week, month, water year)
3. Temperature anomalies (recent week, month)
4. ENSO and other climate indices impact on weather and atmospheric circulation
5. Weather and atmospheric circulation
6. NFDRS, Fire Danger, and other fire potential indicators
7. Drought indices and maps (PDSI, SPI, KBDI, soil moisture, ground water, etc.)
8. Vegetation status (NDVI, Greenness imagery)
9. Fuel moisture (live, dead and foliar if known)
10. Fire occurrence data (number, size, duration if known for current year)
11. Fire behavior observations and/or Farsite run comparisons (if appropriate)

D. Climate and Weather Outlooks

1. Long-range climate outlooks
2. Projected atmospheric circulation
3. ENSO and other relevant index forecasts
4. Drought forecasts (including NCDC drought amelioration)
5. Soil moisture forecasts
6. Fire weather indices

E. Fire Occurrence and Resource Outlooks

1. Estimates on number of fires (based on historic lightning episode information, acres burned, duration, Scripps/Westerling model, and others)
2. Estimates of expected resource needs

F. Future Scenarios and Probabilities

1. Fire Family Plus
2. Priority sub-regions within Geographic Area
3. Fuel-type considerations
4. Climate considerations
5. Season Ending Event Probabilities

G. Management Implications and Concerns

H. Summary and Recommendations